Derivatives of GIT

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M.Sc. Embryology & Histology

Topics

- Derivatives of gut.
- Primitive gut sections.
- Transcription factors specification.
- Fore gut.
- Mid gut.
- Hind gut.

Introduction

- Duo to cephalocaudal and lateral folding of the embryo, a portion of the endoderm derived from gastrulation is incorporated to form the **primitive gut**.
- The yolk sac and the allantois remain outside the embryo.(D)
- In the cephalic and caudal parts of the embryo, the primitive gut forms **a blind-ending tube**.
- The middle part called the midgut, remains temporally connected to the yolk sac by means of the **Vitelline duct** or **yolk stalk**.

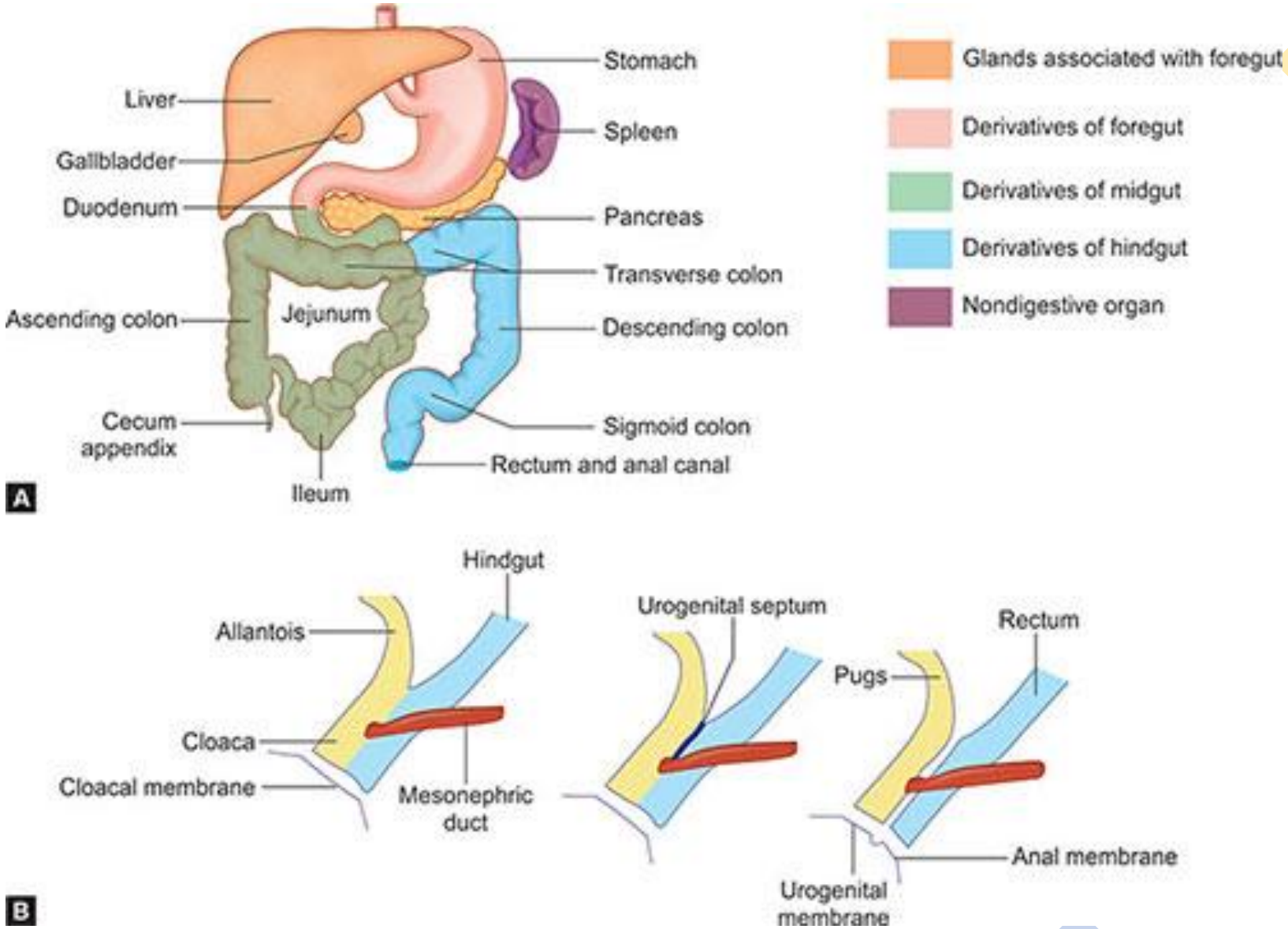
Embryonic Folding

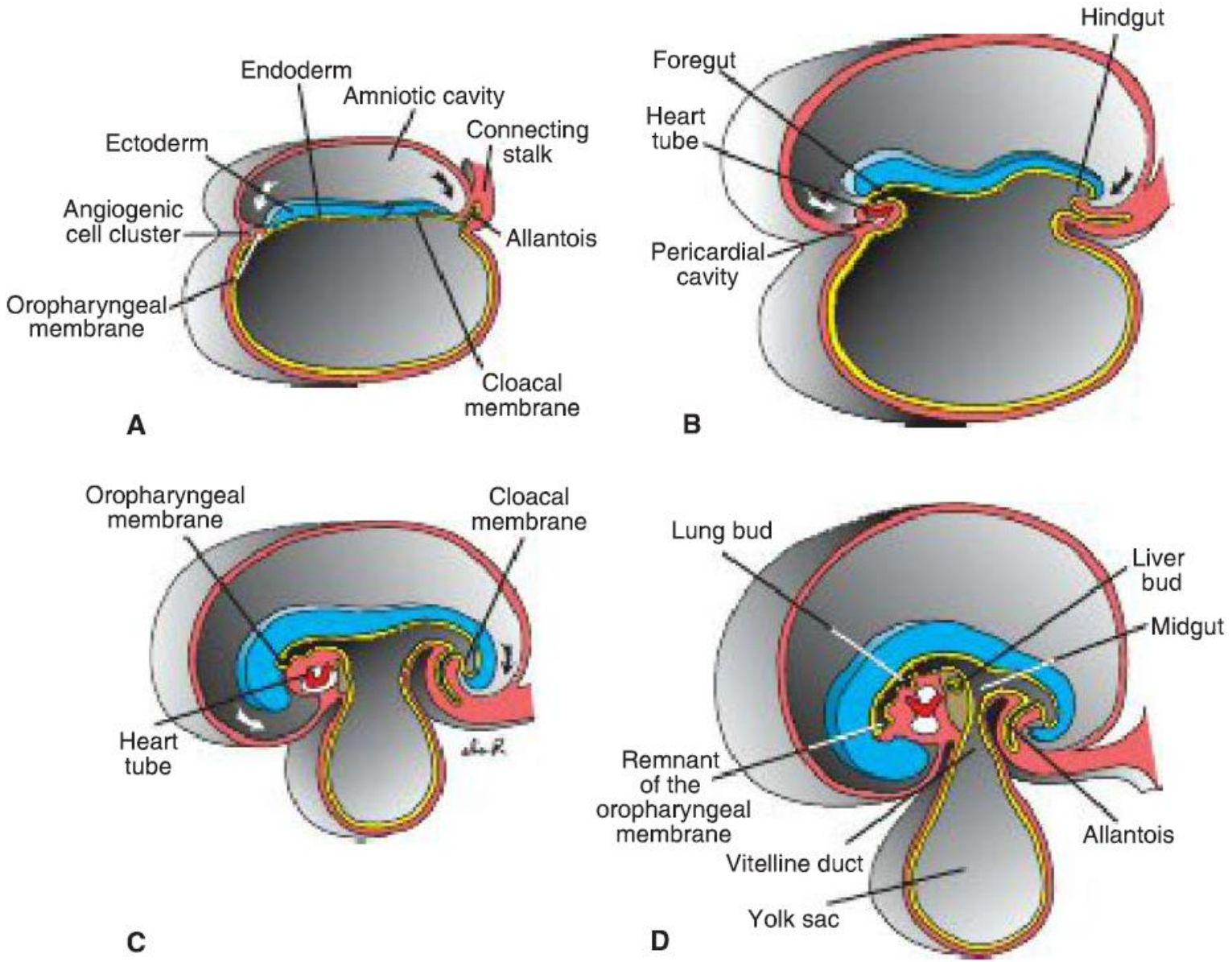
Embryonic folding

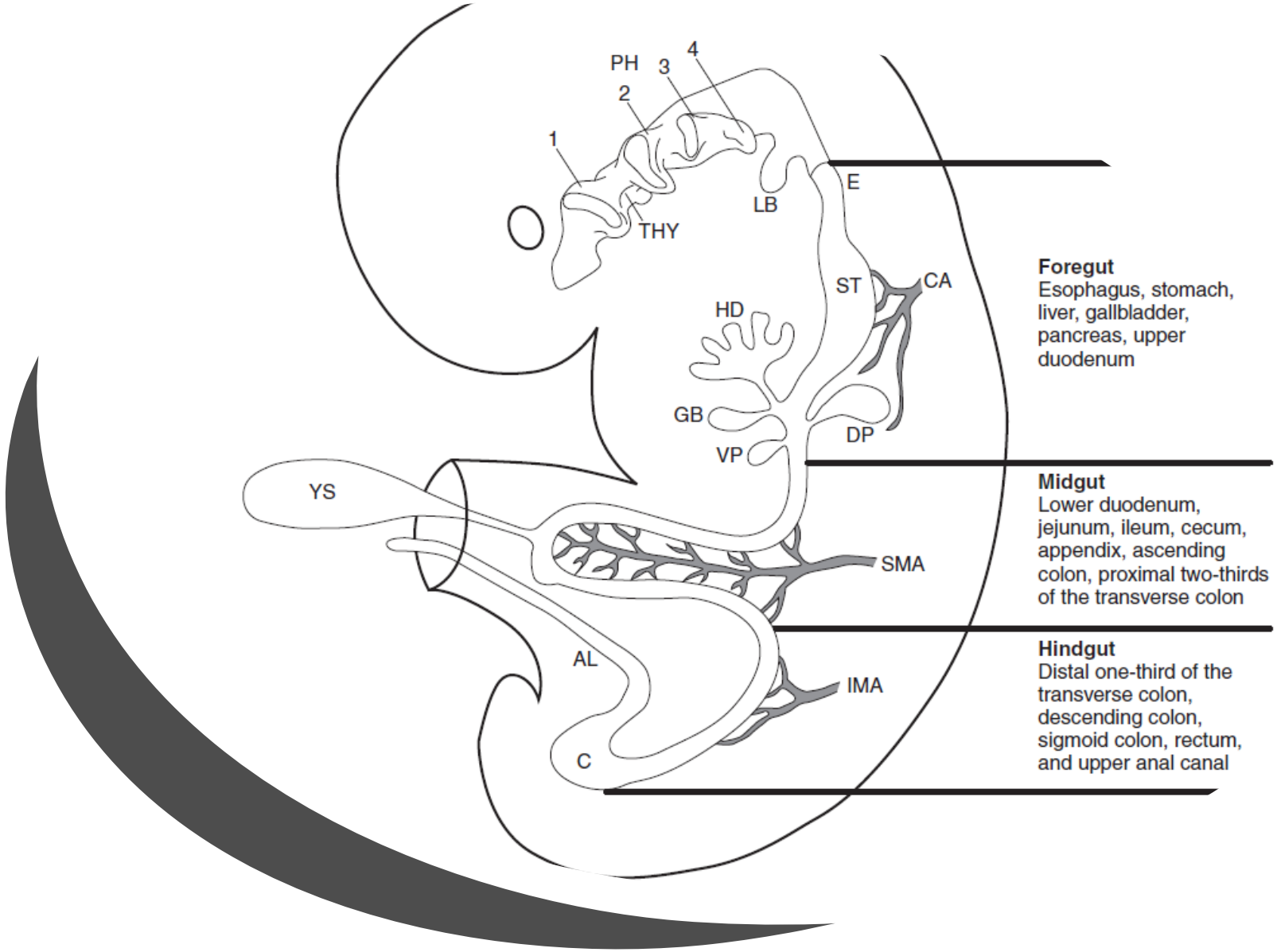
From the fourth week of development, the embryo undergoes a rapid development in size and shape.
The trilaminar disc undergoes a process called embryonic folding
to create a basic three dimensional human body plan.

Derivatives of gut

- **Foregut** : Esophagus, stomach, liver, gallbladder, pancreas, upper duodenum.
- **Midgut** : Lower duodenum, jejunum, ileum, cecum, appendix, ascending colon, proximal two-thirds of the transverse colon.
- **Hindgut** : Distal one-third of the transverse colon, descending colon, sigmoid colon, rectum, and upper anal canal.

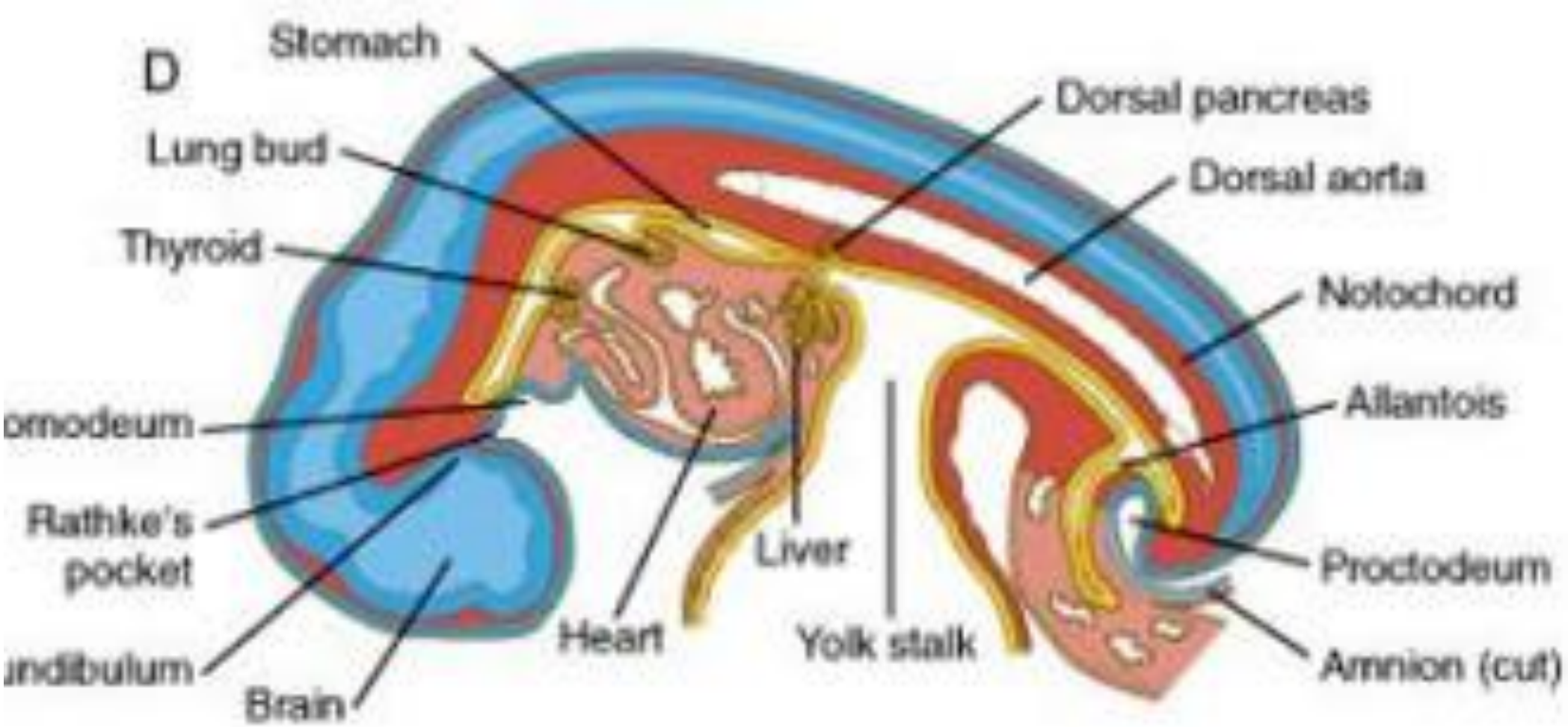

Stomach
Liver
Spleen
Gallbladder
Duodenum
Pancreas
Transverse colon
Ascending colon
Jejunum
Descending colon
Cecum
appendix
Sigmoid colon
Rectum and anal canal
Ileum
A
Glands associated with foregut
Derivatives of foregut
Derivatives of midgut
Derivatives of hindgut
Nondigestive organ
Hindgut
Allantois
Urogenital septum
Rectum
Pugs
Cloaca
Cloacal membrane
Mesonephric
duct
Anal membrane
Urogenital
membrane
B


Endoderm
Amniotic cavity
Ectoderm
Connecting stalk
Angiogenic cell cluster
Allantois
Oropharyngeal membrane
Cloacal membrane
A
Hindgut
Foregut
Heart tube
Pericardial cavity
B
Oropharyngeal membrane
Cloacal membrane
Heart tube
C
Lung bud
Liver bud
Midgut
Remnant of the oropharyngeal membrane
Allantois
Vitelline duct
Yolk sac
D


PH
3
4
2
1
E
LB
THY
ST
CA
HD
GB
DP
VP
YS
SMA
AL
IMA
C
Foregut
Esophagus, stomach, liver, gallbladder, pancreas, upper duodenum
Midgut
Lower duodenum, jejunum, ileum, cecum, appendix, ascending colon, proximal two-thirds of the transverse colon
Hindgut
Distal one-third of the transverse colon, descending colon, sigmoid colon, rectum, and upper anal canal

Primitive gut sections

- The pharyngeal gut, extends from the oropharyngeal membrane to the **respiratory diverticulum** and is part of the foregut; this section is particularly important for development of the **head and neck**.
- The remainder of the foregut lies caudal to the pharyngeal tube and extends caudally as the **liver** outgrowth.
- The midgut begins caudal to the liver bud and extends to the junction of the right two-thirds and left third of the transverse colon in the adult.
- The hindgut extends from the left third of the transverse colon to the cloacal membrane.


D
Stomach
Lung bud
Thyroid
ormodeum
Rathke's pocket
ndibulum
Brain
Heart
Liver
Yolk stalk
Dorsal pancreas
Dorsal aorta
Notochord
Allantois
Proctodeum
Amnion (cut)

- Endoderm forms the epithelial lining of the digestive tract and gives rise to the specific cells (parenchyma) of glands, such as **hepatocytes** and the **exocrine** and **endocrine** cells of the **pancreas**.
- The stroma for the glands muscle, connective tissue and peritoneal are derived from **visceral mesoderm**.

Specification

Regional specification of the gut tube into different components occurs during the time that the lateral body folds are bringing the two sides of the tube together.

The specification is initiated by a concentration of **Retinoic acid** (RA) from the pharynx, which is exposed to little, While in the colon, which sees the highest concentration of RA. This RA gradient causes transcription factors to be expressed in different regions of the gut tube.

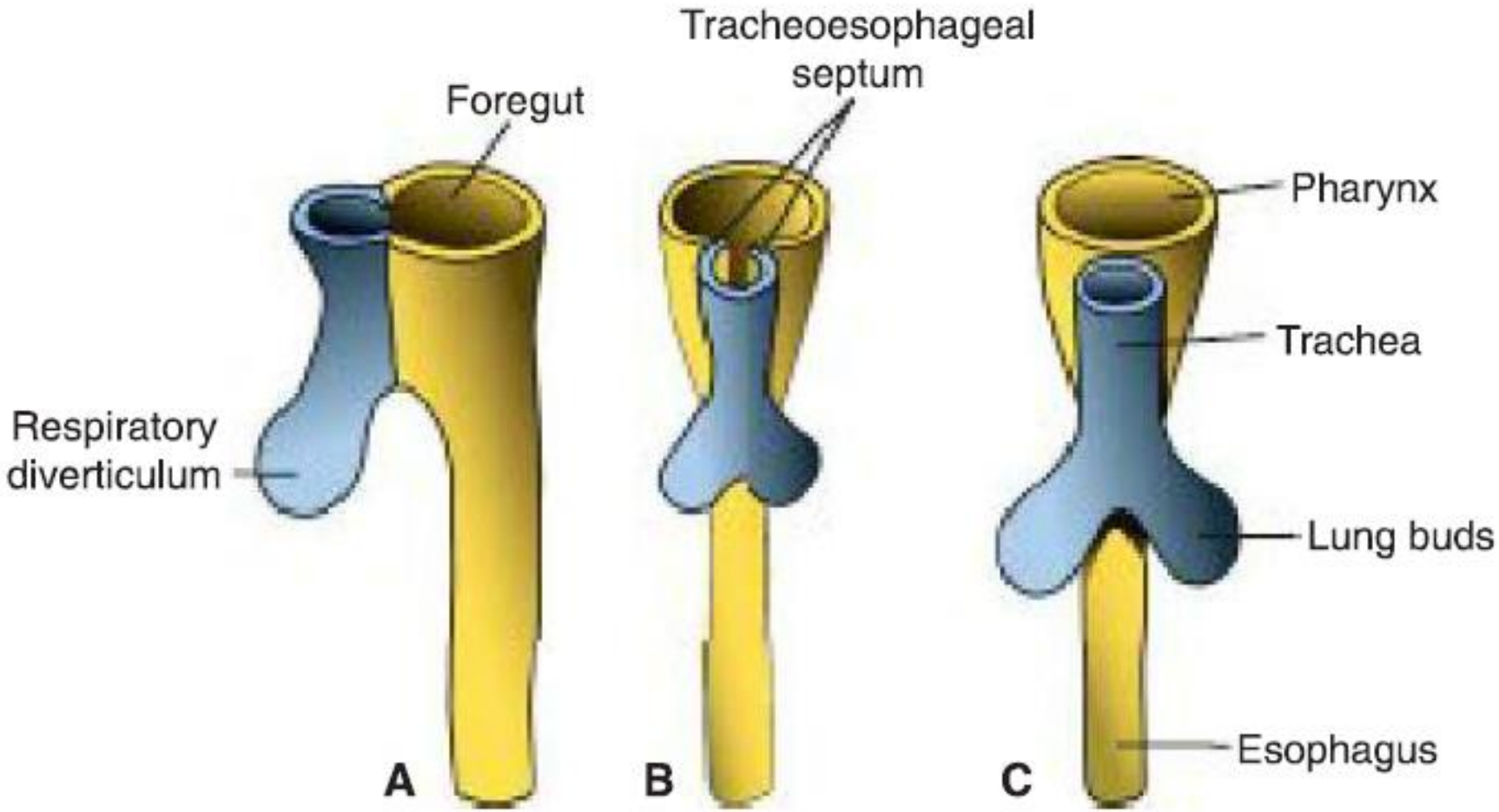
Transcription factors specification

1. SOX2 for the esophagus and stomach
2. PDX1 for duodenum;
3. CDXC for small intestine
4. CDXA for the large intestine & rectum

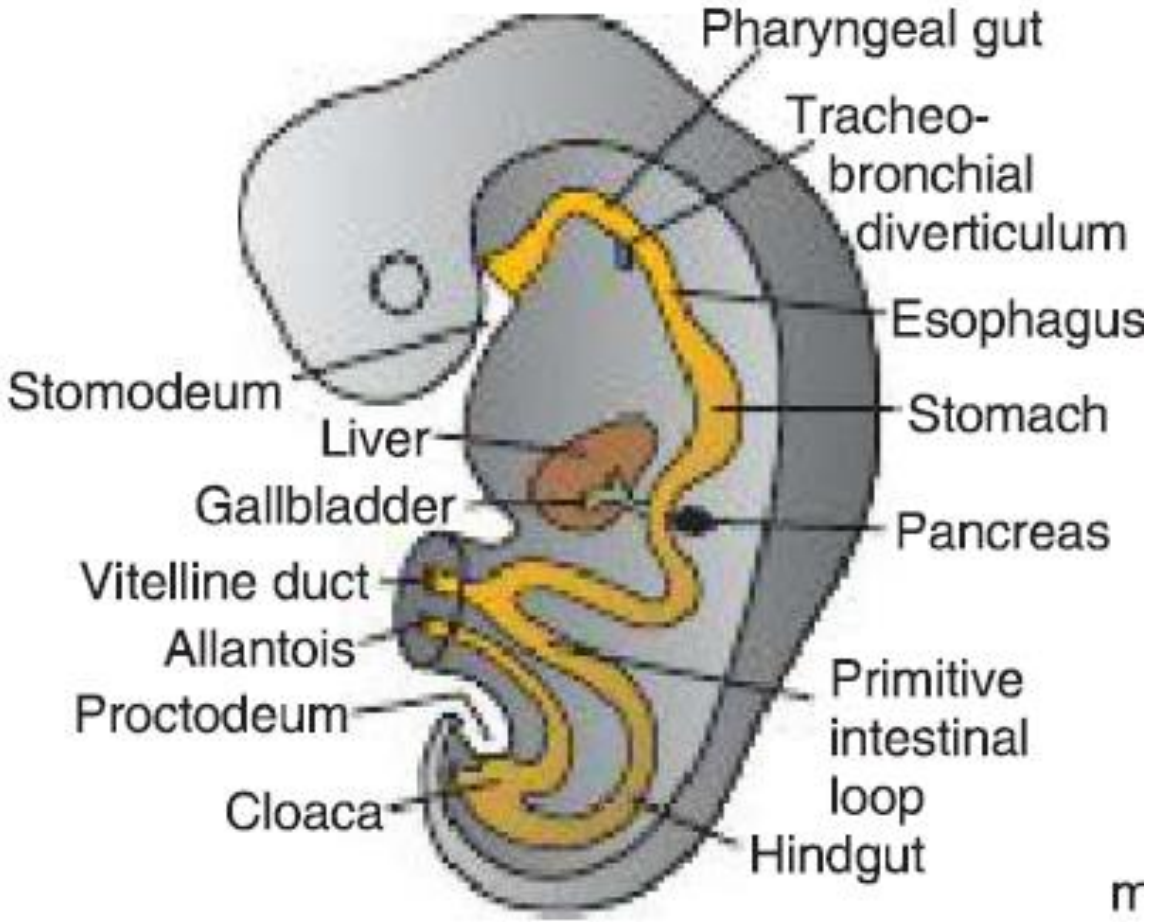
Foregut

- Esophagus
  When the embryo is **4 weeks** old, the respiratory diverticulum (lung bud) appears at the ventral wall of the foregut at the border with the pharyngeal gut.

  The **tracheoesophageal septum** gradually partitions this diverticulum from the dorsal part of the foregut


Tracheoesophageal septum
Foregut
Respiratory diverticulum
Pharynx
Trachea
Lung buds
Esophagus
A
B
C

- The foregut divides into a ventral portion, the **respiratory primordium**, and a dorsal portion, the **esophagus**.
- At first, the esophagus is short, but with descent of the heart and lungs, then lengthens rapidly.
- The muscular coat is formed by surrounding visceral mesenchyme, is **striated** in its upper two-thirds and innervated by the **vagus**; while the muscle coat is **smooth** in the lower third and is innervated by the **splanchnic plexus**.

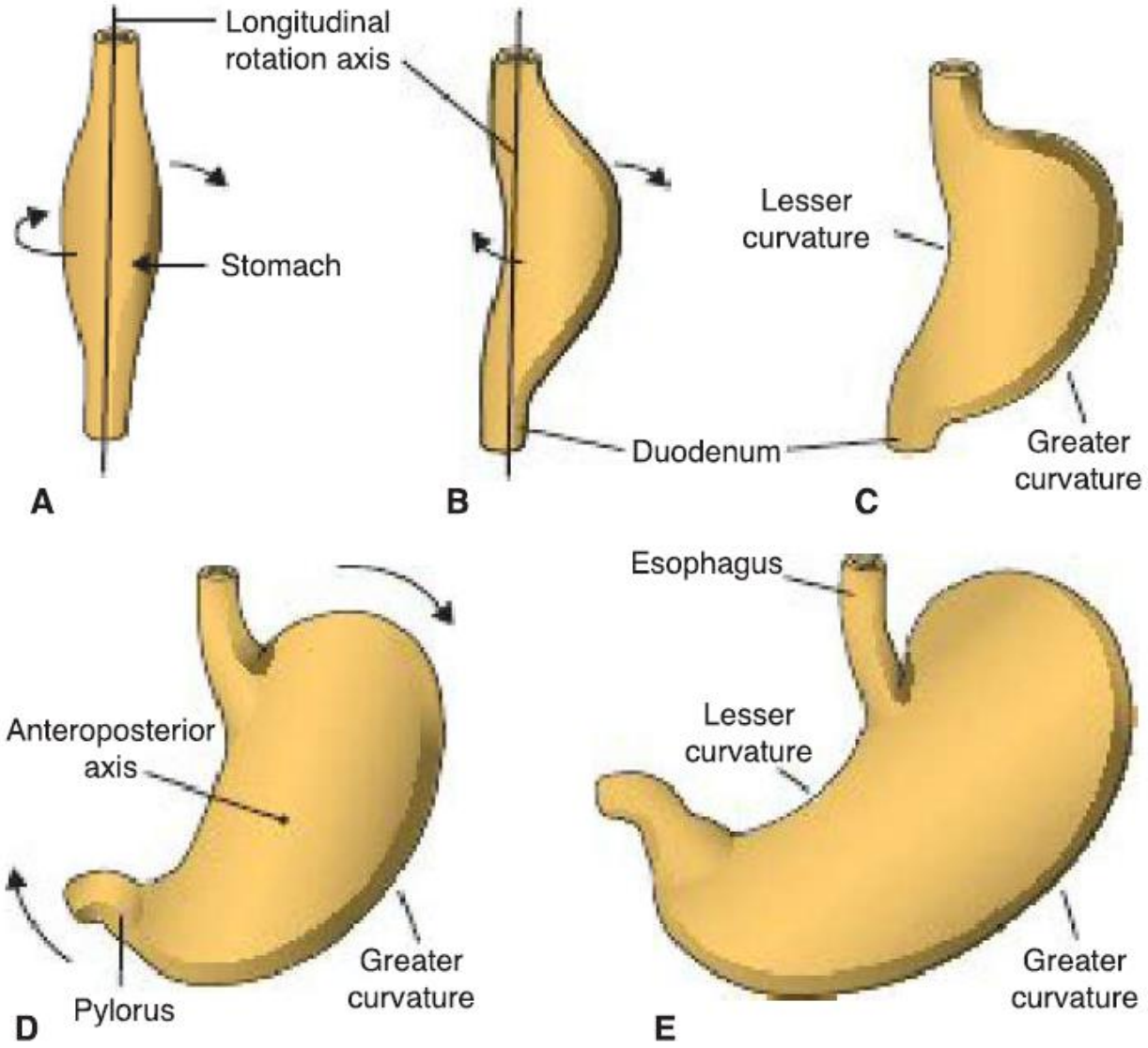

Pharyngeal gut
Tracheo-
bronchial
diverticulum
Esophagus
Stomodeum
Stomach
Liver
Gallbladder
Pancreas
Vitelline duct
Allantois
Primitive
intestinal
loop
Proctodeum
Cloaca
Hindgut

- Stomach

The stomach begins its development from the foregut in the **4th week** as a fusiform dilation in close approximation to the respiratory diverticulum in the primitive thoracic region.

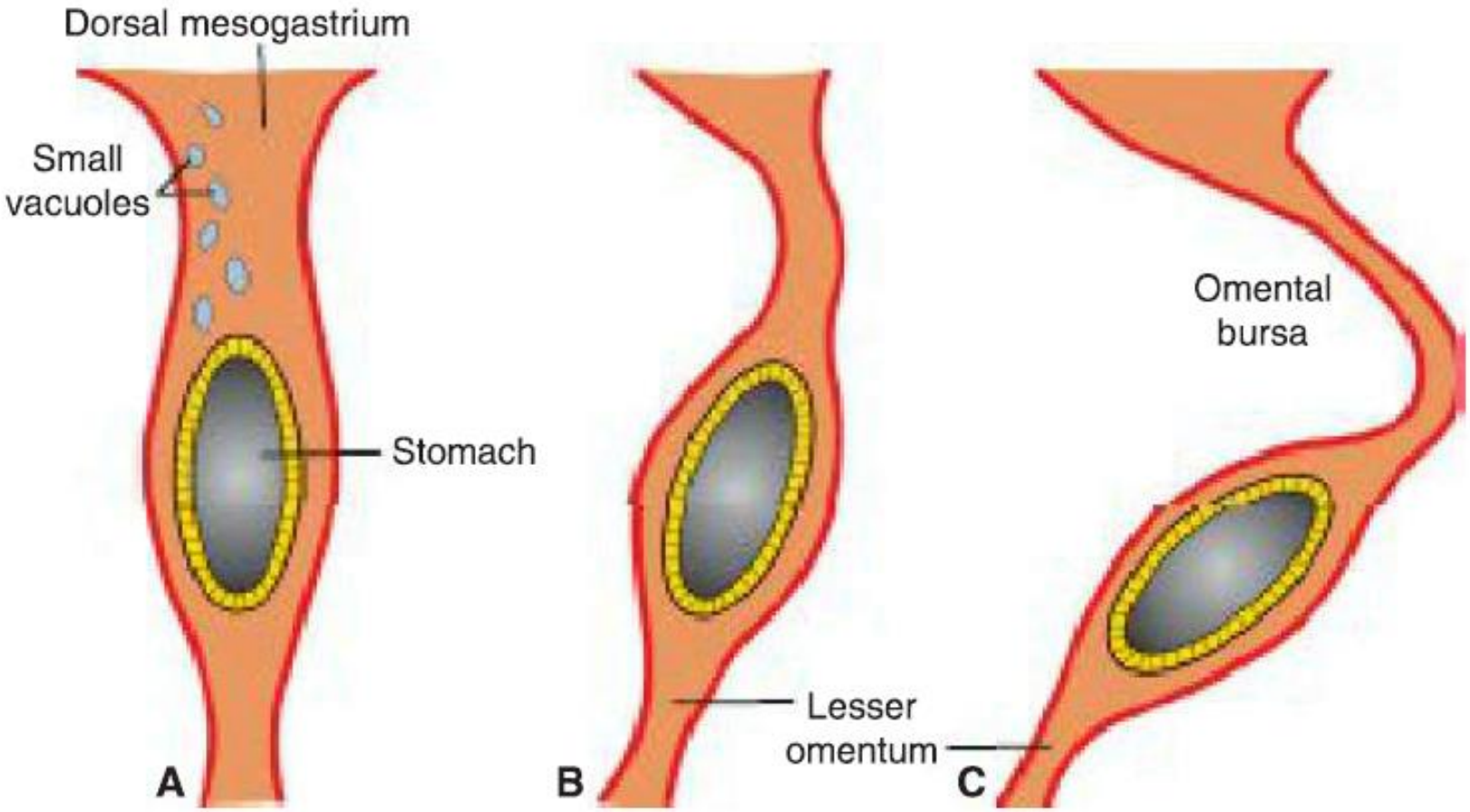
Growth to lengthen the esophageal region is essential for positioning the stomach in the abdominal cavity below the diaphragm.

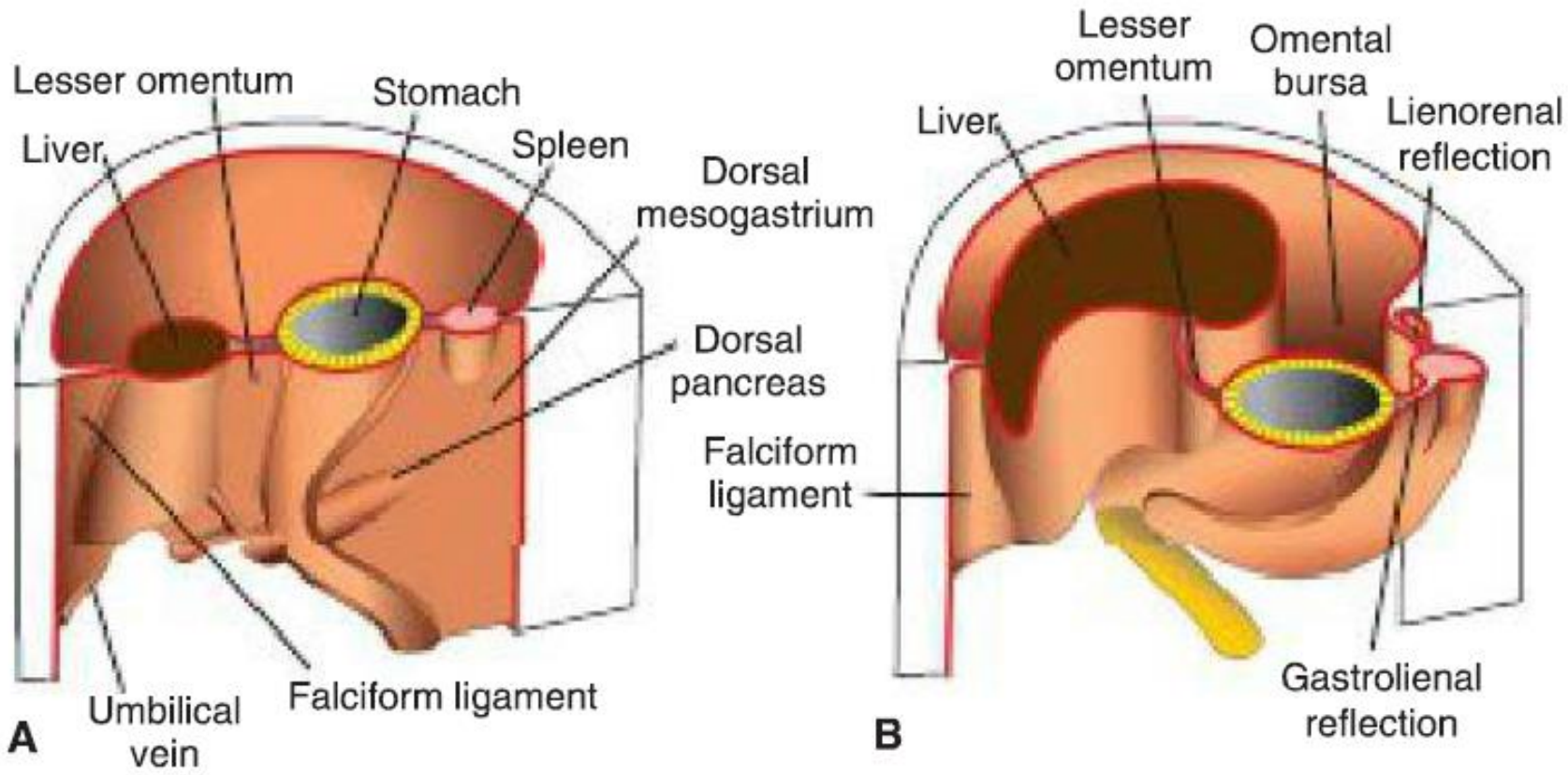
After lengthening of the esophageal region of the foregut has occurred, the appearance and position of the stomach change greatly as a result of the different rates of growth in various regions of its wall and the changes in position of surrounding organs.


Longitudinal
rotation axis
Stomach
A
B
Lesser
curvature
Duodenum
Greater
curvature
C
Anteroposterior
axis
Pylorus
Greater
curvature
D
Esophagus
Lesser
curvature
Greater
curvature
E

- Positional changes of the stomach are most easily The stomach rotates 90° clockwise around its **longitudinal axis**, causing its left side to face anteriorly and its right side to face posteriorly.
- During this rotation, the original posterior wall of the stomach grows faster than the anterior portion, forming the **greater** and **lesser curvatures**.
- The cephalic and caudal ends of the stomach originally lie in the midline, but during further growth, the stomach rotates around an **anteroposterior axis**, such that the caudal or **pyloric part** moves to the right and upward, and the cephalic or **cardiac portion** moves to the left and slightly downward.

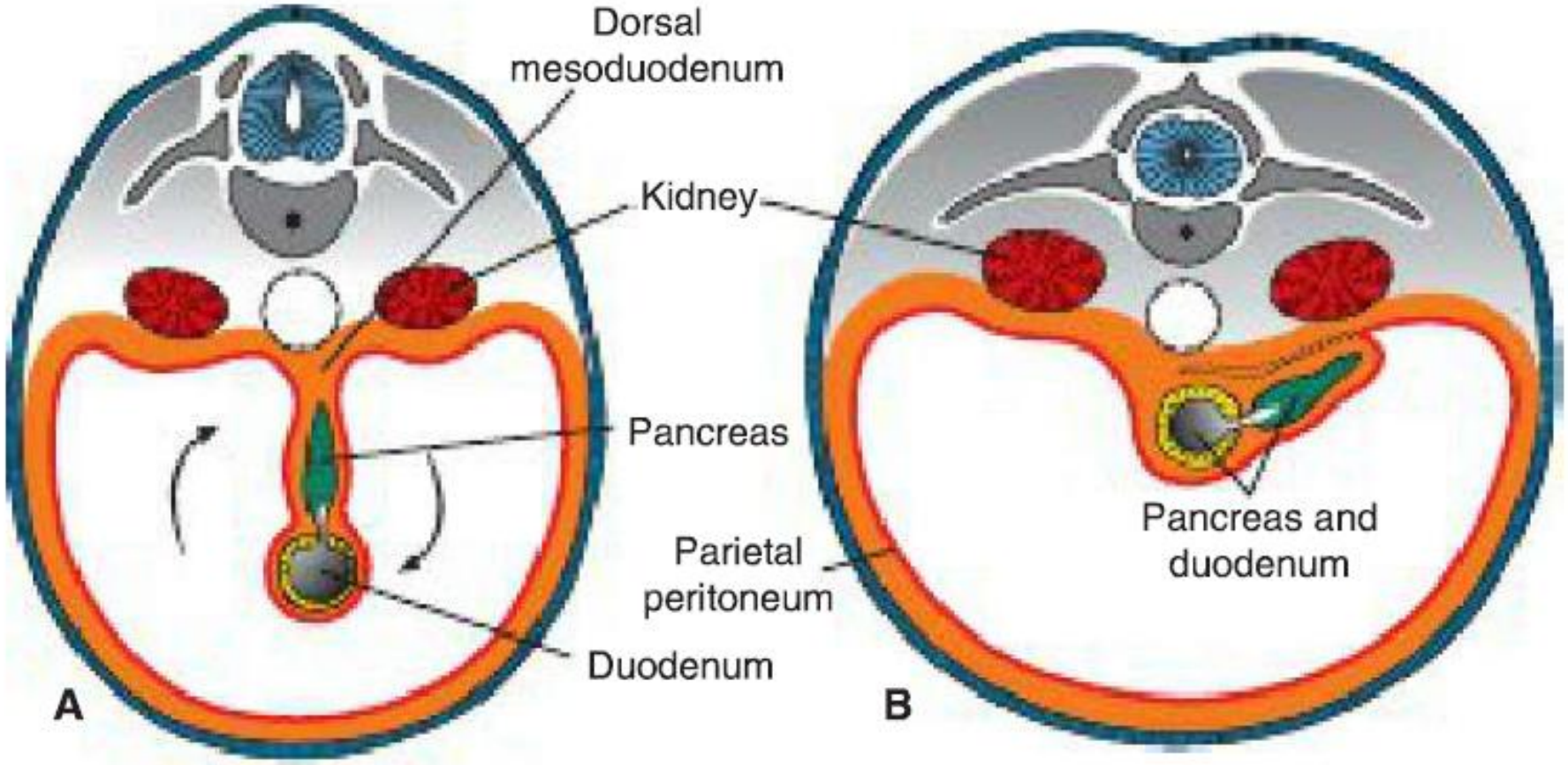
- The stomach is attached to the dorsal body wall by the **dorsal mesogastrium** and to the ventral body wall by the **ventral mesogastrium**, which is part of the septum transversum.
- As the liver grows into this region, mesoderm forming ventral mesogastrium becomes thinner and forms the two parts of the ventral mesentery
  (1) the lesser omentum, connecting the stomach to the liver.
  (2) the falciform ligament, connecting the liver to the ventral body wall.


Dorsal mesogastrium
Small vacuoles
Stomach
A
B
Lesser omentum
Omental bursa
C


Lesser omentum
Stomach
Liver
Spleen
Dorsal mesogastrium
Dorsal pancreas
Falciform ligament
Umbilical vein
Falciform ligament
A
Lesser omentum
Omental bursa
Liver
Lienorenal reflection
Gastrolienal reflection
B

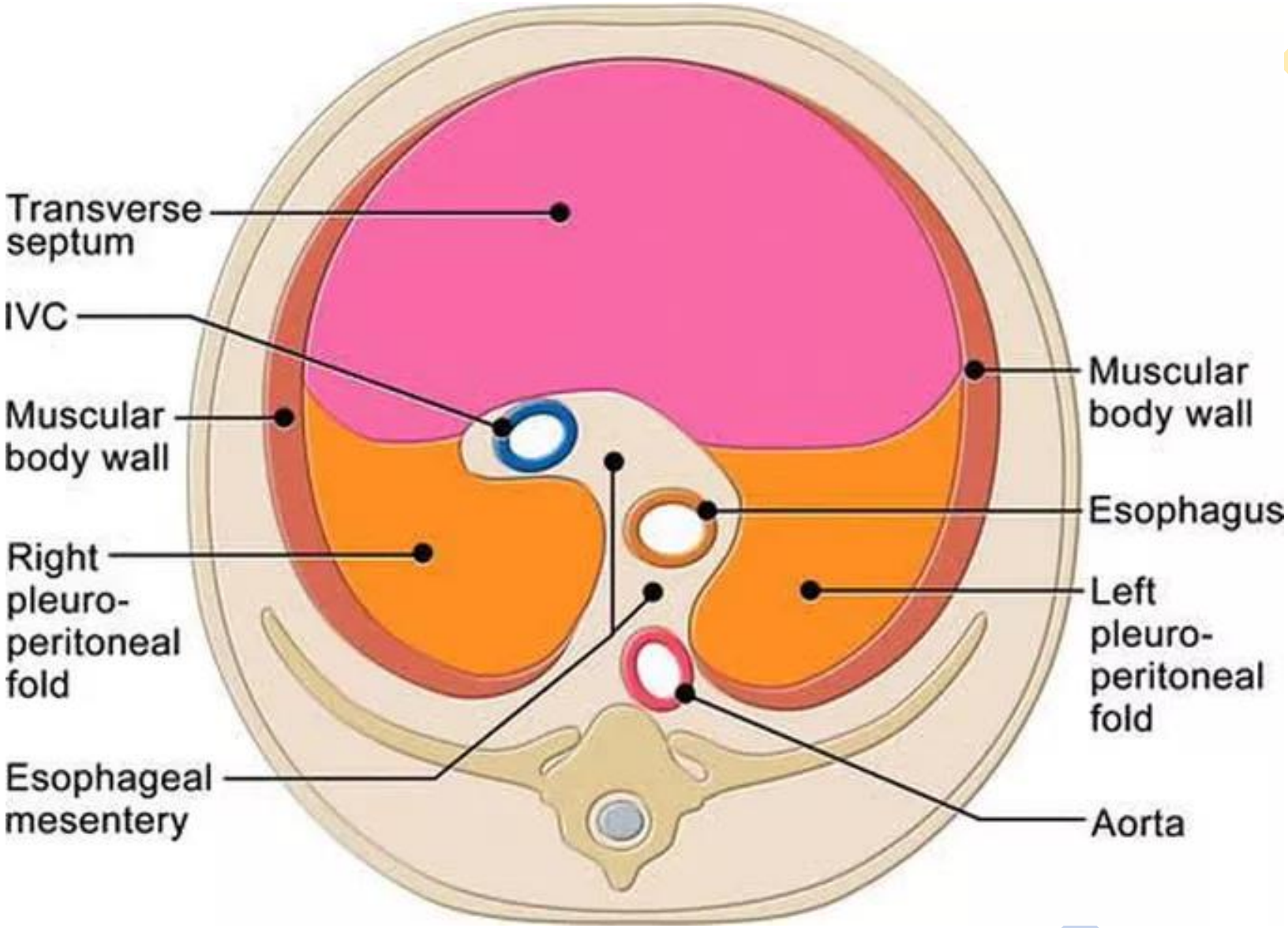
Duodenum

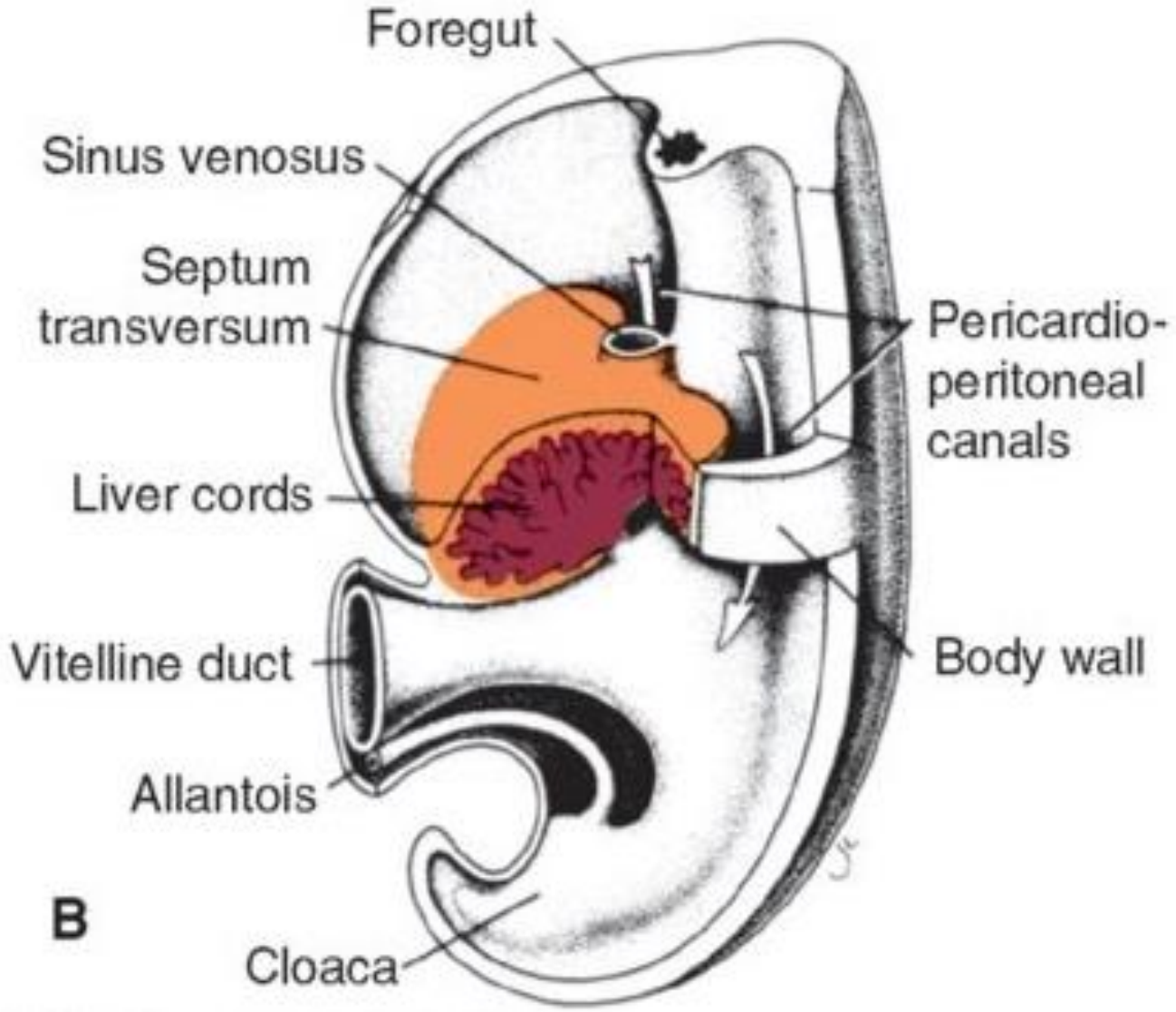
- The terminal part of the foregut and the cephalic part of the midgut form the duodenum. The junction of the two parts is directly distal to the origin of the liver bud.
- As the stomach rotates, the duodenum takes on the form of a C-shaped loop and rotates to the right. This rotation, together with rapid growth of the head of the pancreas, swings the duodenum from initial midline position to the right side of the abdominal cavity.
- The pancreas and most of the duodenum become attached to the posterior body wall.
- A small portion of the distal region of the duodenum (**duodenal cap**) retains an extension of mesentery and remains unattached to the posterior body wall.
- During the second month, the lumen of the duodenum is obliterated by proliferation of cells in its walls. However, the lumen is recanalized after short time.

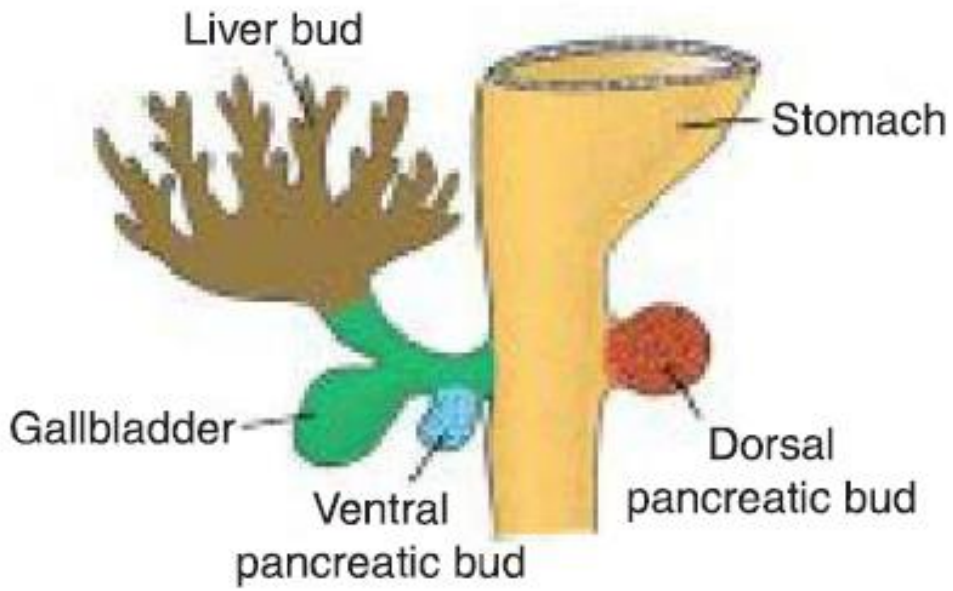

Dorsal
mesoduodenum
Kidney
Pancreas
Parietal
peritoneum
Duodenum
A
Pancreas and
duodenum
B

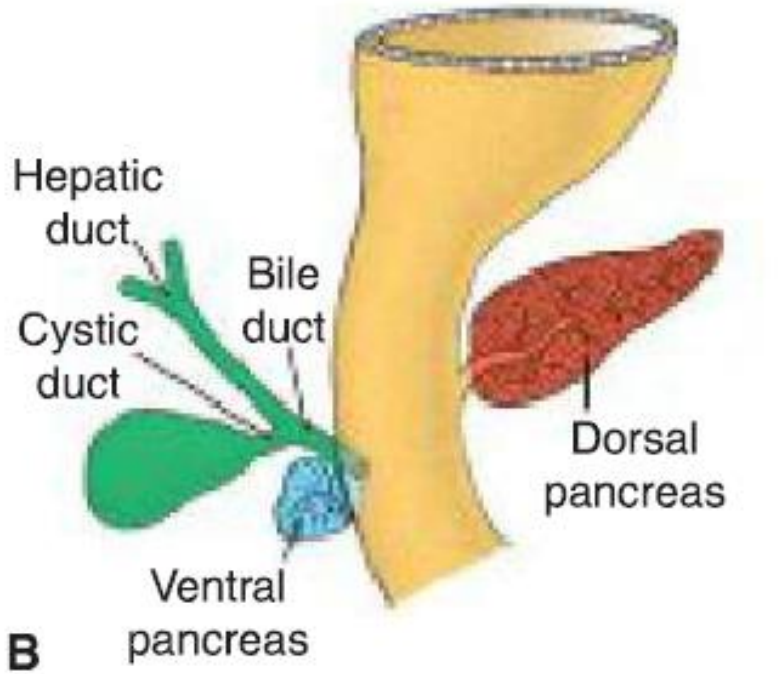
Liver and Gallbladder

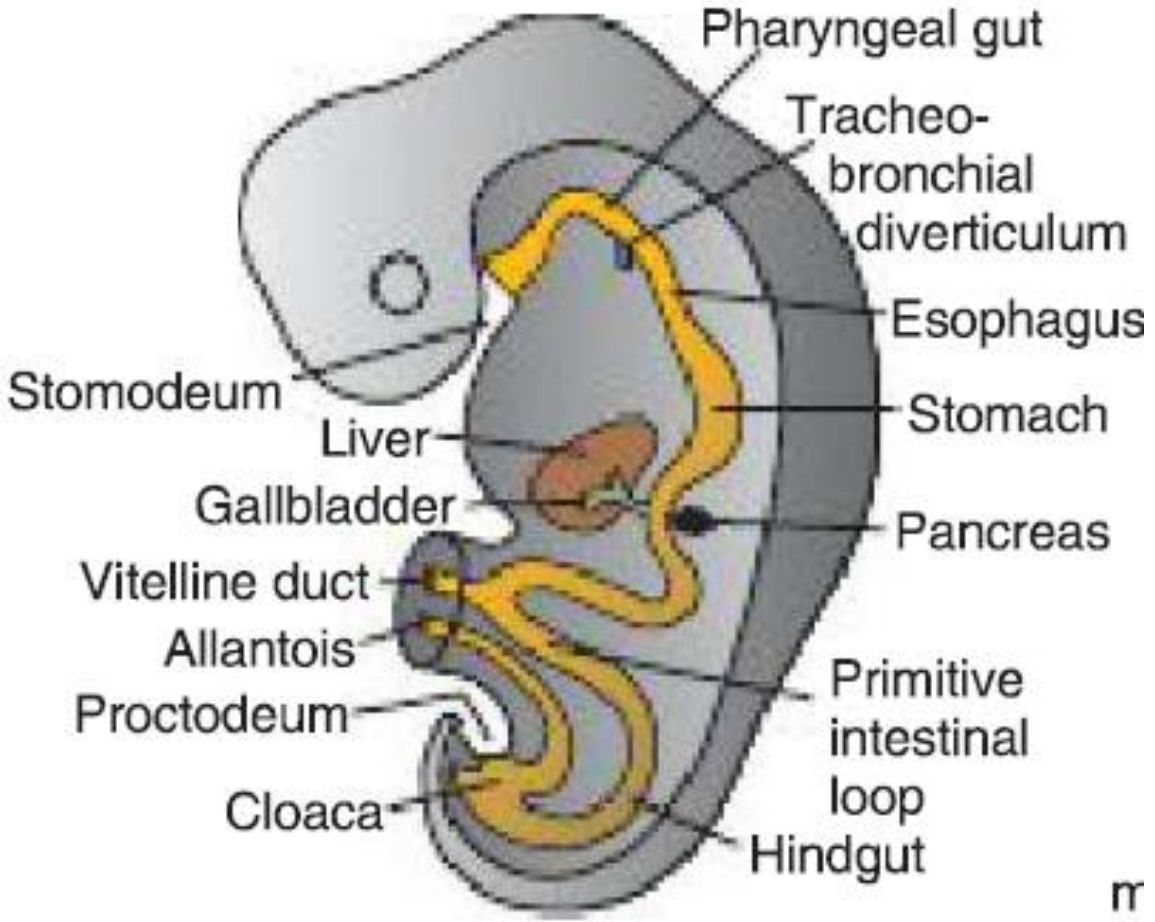
- The liver primordium appears in **the middle of the 3rd week** as an outgrowth of the endodermal epithelium at the distal end of the foregut.
- The hepatic diverticulum or liver bud, consists of rapidly proliferating cells that penetrate the **septum transversum**, , the mesodermal plate between the pericardial cavity and the stalk of the yolk sac.
- Hepatic cells continue to penetrate the septum, the connection between the hepatic diverticulum and the foregut (duodenum) narrows, forming the bile duct A small ventral outgrowth, and this outgrowth gives rise to the gallbladder and the cystic duct.


Transverse septum
IVC
Muscular body wall
Right pleuro-peritoneal fold
Esophageal mesentery
Muscular body wall
Esophagus
Left pleuro-peritoneal fold
Aorta

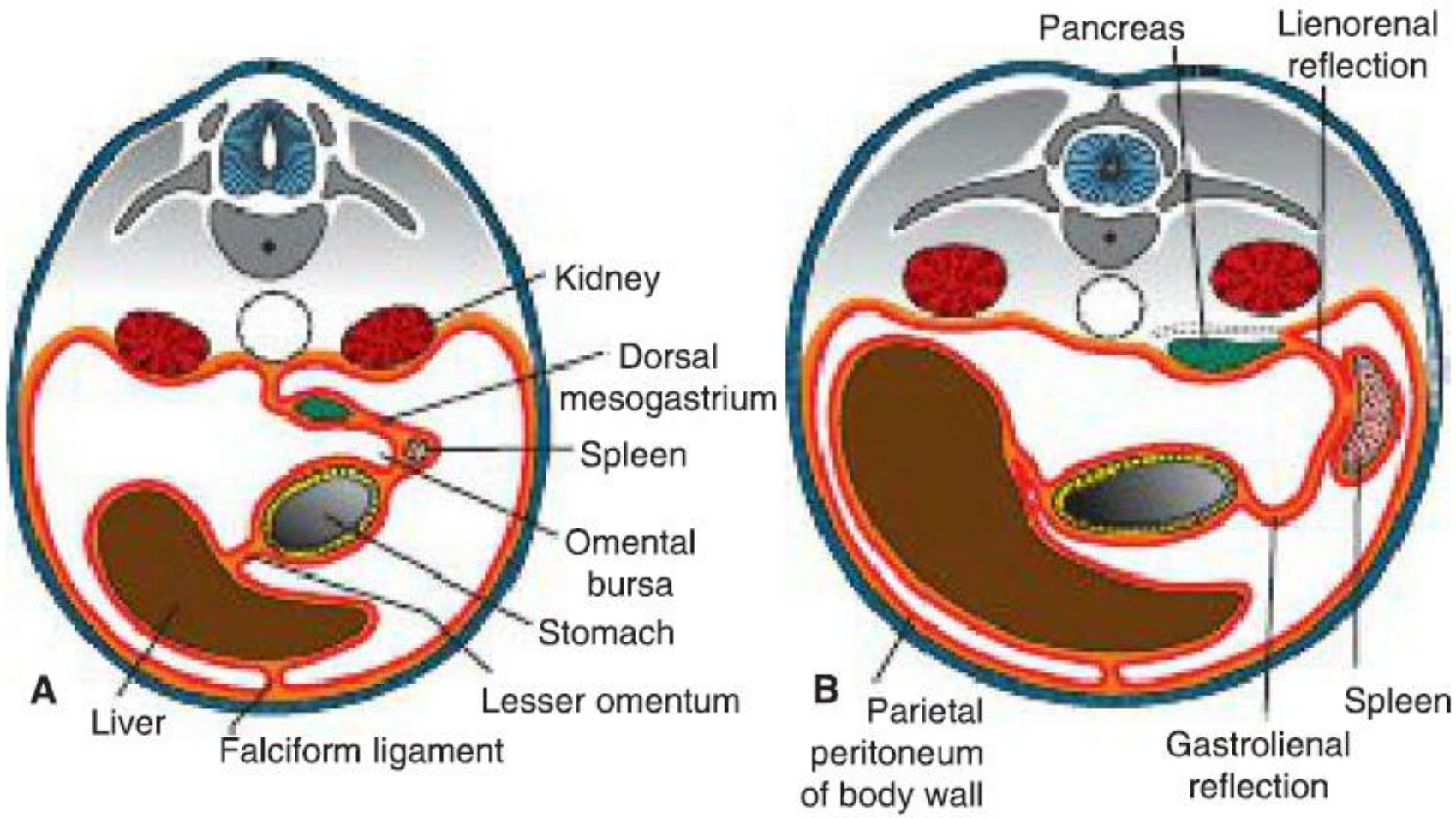

Foregut
Sinus venosus
Septum transversum
Liver cords
Vitelline duct
Allantois
Cloaca
Pericardio-peritoneal canals
Body wall
B


Liver bud
Stomach
Gallbladder
Ventral pancreatic bud
Dorsal pancreatic bud
A


Hepatic duct
Bile duct
Cystic duct
Dorsal pancreas
Ventral pancreas
B


Pharyngeal gut
Tracheo-
bronchial
diverticulum
Esophagus
Stomodeum
Stomach
Liver
Gallbladder
Pancreas
Vitelline duct
Allantois
Primitive
intestinal
loop
Proctodeum
Cloaca
Hindgut

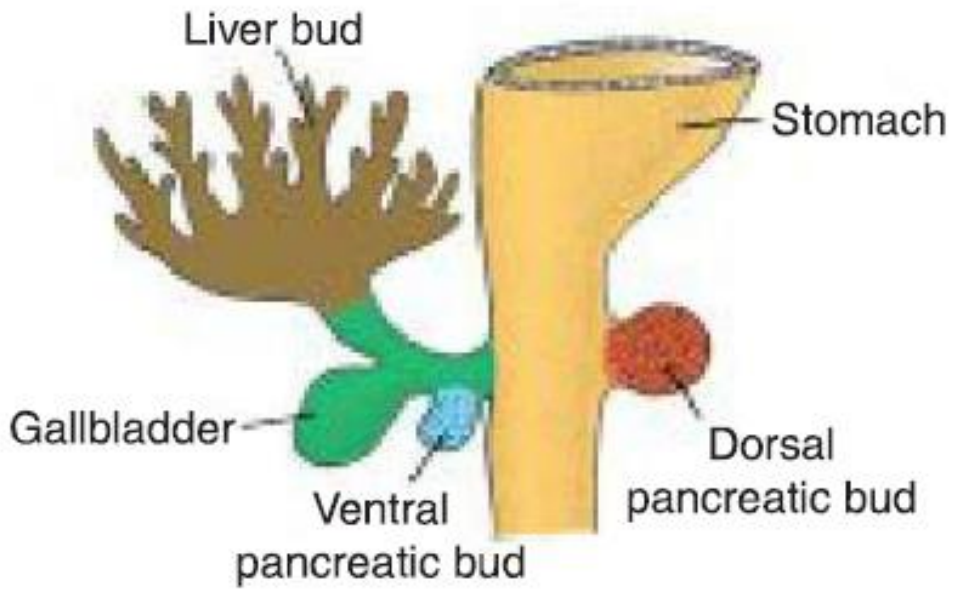
- Liver cords differentiate into the **parenchyma** (liver cells) and form the lining of the biliary ducts.
- **Hematopoietic cells, Kupffer cells**, and connective tissue cells are derived from mesoderm of the **septum transversum**.
- liver cells have invaded the entire septum transversum, so that the organ bulges caudally into the abdominal cavity, mesoderm of the septum transversum lying between the liver and the foregut and the liver and the ventral abdominal wall becomes membranous, forming the **lesser omentum and falciform ligament**

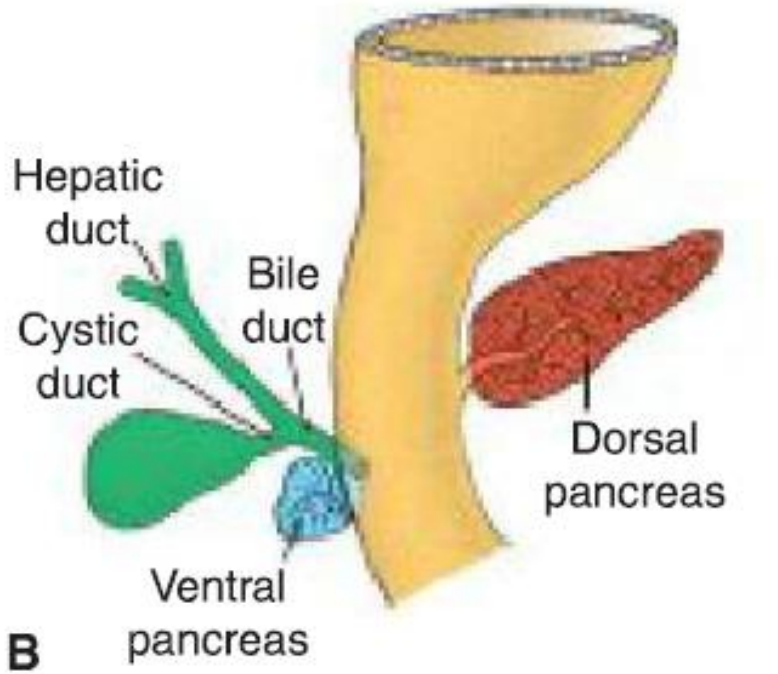

Kidney
Dorsal mesogastrium
Spleen
Omental bursa
Stomach
Lesser omentum
A
Liver
Falciform ligament
Pancreas
Lienorenal reflection
B
Parietal peritoneum of body wall
Spleen
Gastrolienal reflection

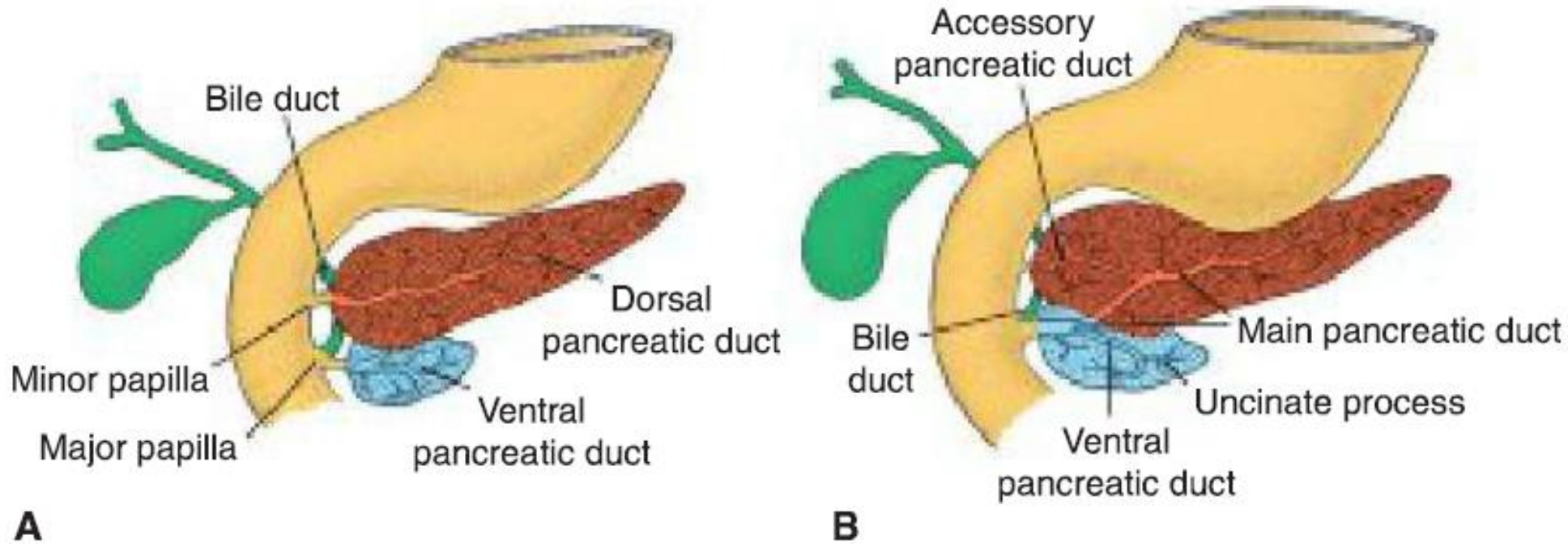
Pancreas

- The pancreas is formed by two buds, dorsal and ventral, originating from the endodermal lining of the duodenum.
- The dorsal pancreatic bud is in the dorsal mesentery, the ventral pancreatic bud is close to the bile duct.
- the duodenum rotates to the right and becomes C-shaped, the ventral pancreatic bud moves dorsally in a manner similar to the shifting of the entrance of the bile duct.
- the ventral bud comes to lie immediately below and the dorsal bud Later, the parenchyma and the duct systems of the dorsal and ventral pancreatic buds fuse.

- The ventral bud forms **the uncinate process** and **inferior part of the head of the pancreas**. the remaining part of the gland is derived from the dorsal bud.
- The main pancreatic duct is formed by **the distal part of the dorsal pancreatic duct and the entire ventral pancreatic duct**, The proximal part of the dorsal pancreatic duct persists as a small channel, called **accessory pancreatic duct**.
- In the **third month** pancreatic islets develop from the **parenchymatous pancreatic tissue, Insulin secretion** begins at approximately the **fifth month**.


Liver bud
Stomach
Gallbladder
Ventral pancreatic bud
Dorsal pancreatic bud
A

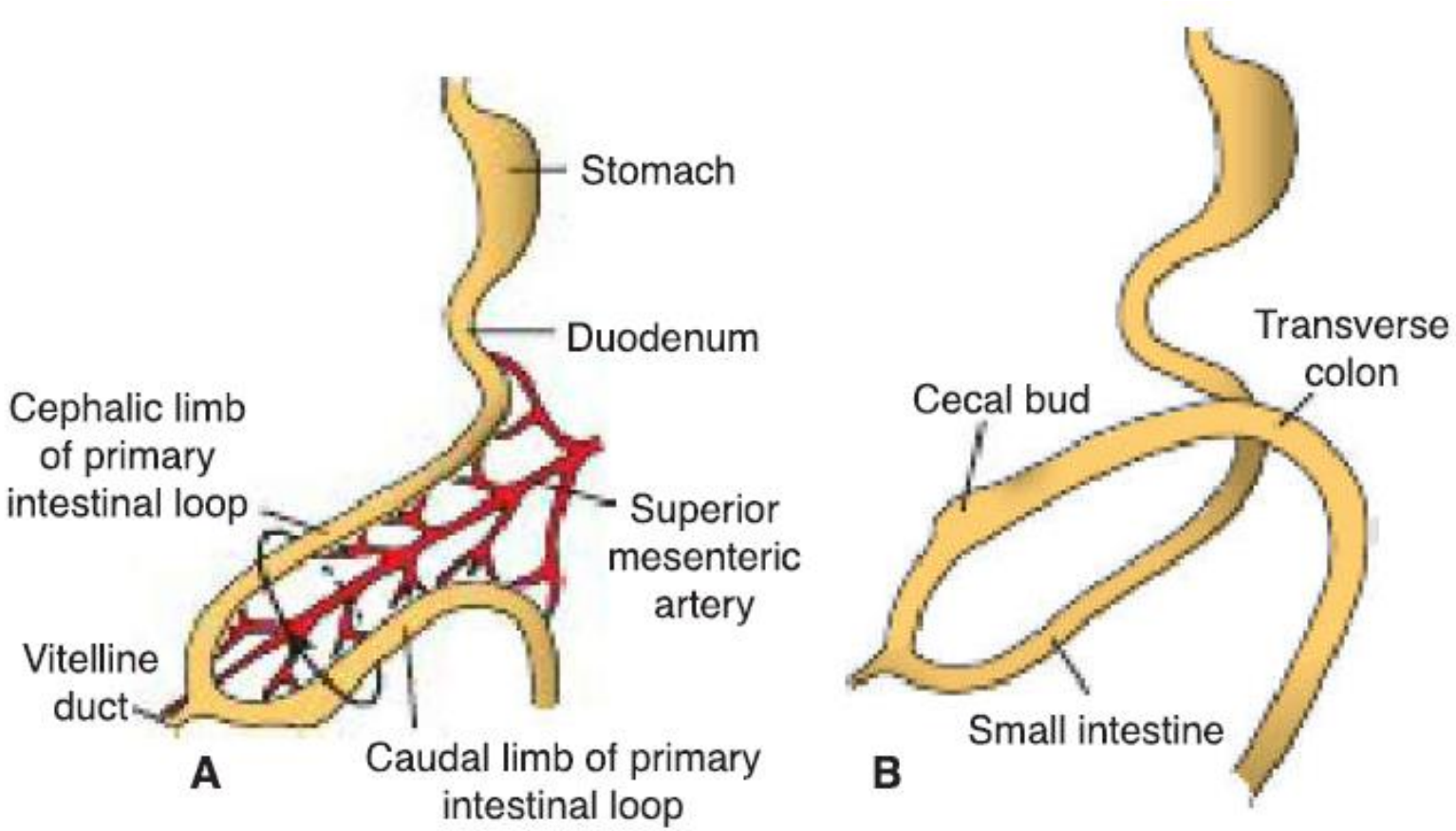

Hepatic duct
Bile duct
Cystic duct
Dorsal pancreas
Ventral pancreas
B

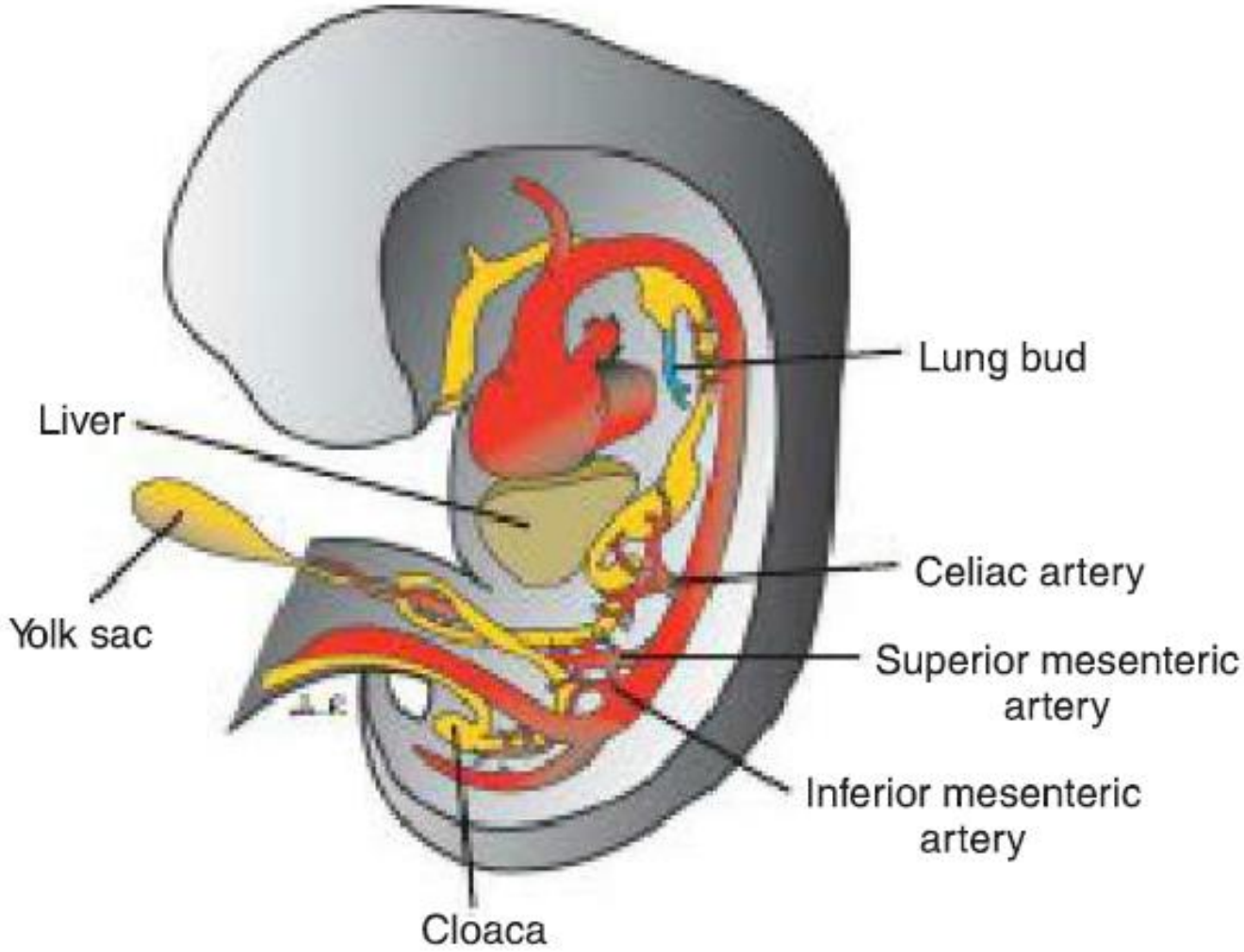

Bile duct
Dorsal pancreatic duct
Minor papilla
Major papilla
Ventral pancreatic duct
A
Accessory pancreatic duct
Bile duct
Main pancreatic duct
Uncinate process
Ventral pancreatic duct
B

MID gut

- In the **5-week** embryo, the midgut is suspended from the dorsal abdominal wall by a **short mesentery** and communicates with the yolk sac by way of the **vitelline duct** or yolk stalk.
- the midgut begins immediately distal to the entrance of the bile duct into the duodenum and terminates at the junction of the proximal two-thirds of the transverse colon with the distal third.
- Over its entire length, the midgut is supplied by the **superior mesenteric artery**.
- Development of the midgut is resulting in formation of **the primary intestinal loop**

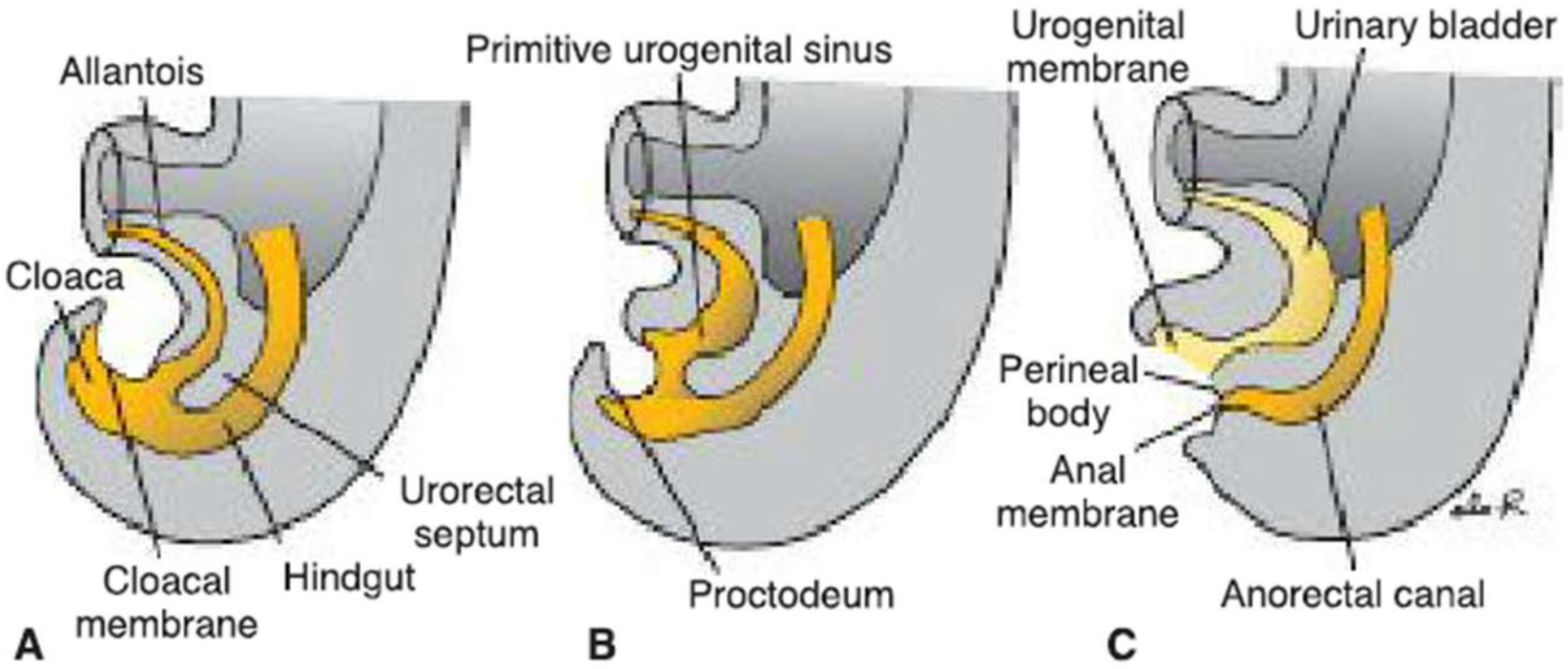
- The cephalic limb of the loop develops into the **distal part of the duodenum, the jejunum, and part of the ileum**.
- The caudal limb becomes. the lower portion of **the ileum, the cecum, the appendix, the ascending colon, and the proximal two-thirds of the transverse colon**.
- the primary intestinal loop rotates around an axis formed by the superior mesenteric artery.


Stomach
Duodenum
Cephalic limb of primary intestinal loop
Superior mesenteric artery
Vitelline duct
Caudal limb of primary intestinal loop
A
Transverse colon
Cecal bud
Small intestine
B


Lung bud
Liver
Celiac artery
Yolk sac
Superior mesenteric artery
Inferior mesenteric artery
Cloaca

HINDGUT

- The hindgut gives rise to the distal third of the transverse colon, the descending colon, the sigmoid, the rectum, and the upper part of the anal canal.
- The endoderm of the hindgut also forms, the terminal portion of the hindgut to the posterior region of the **cloaca**, called the **primitive anorectal canal.**
- The allantois form the anterior portion that is called the **primitive urogenital sinus**.
- The cloaca is an endoderm-lined cavity covered at its ventral boundary by surface ectoderm. This boundary between the endoderm and the ectoderm forms the **cloacal membrane**

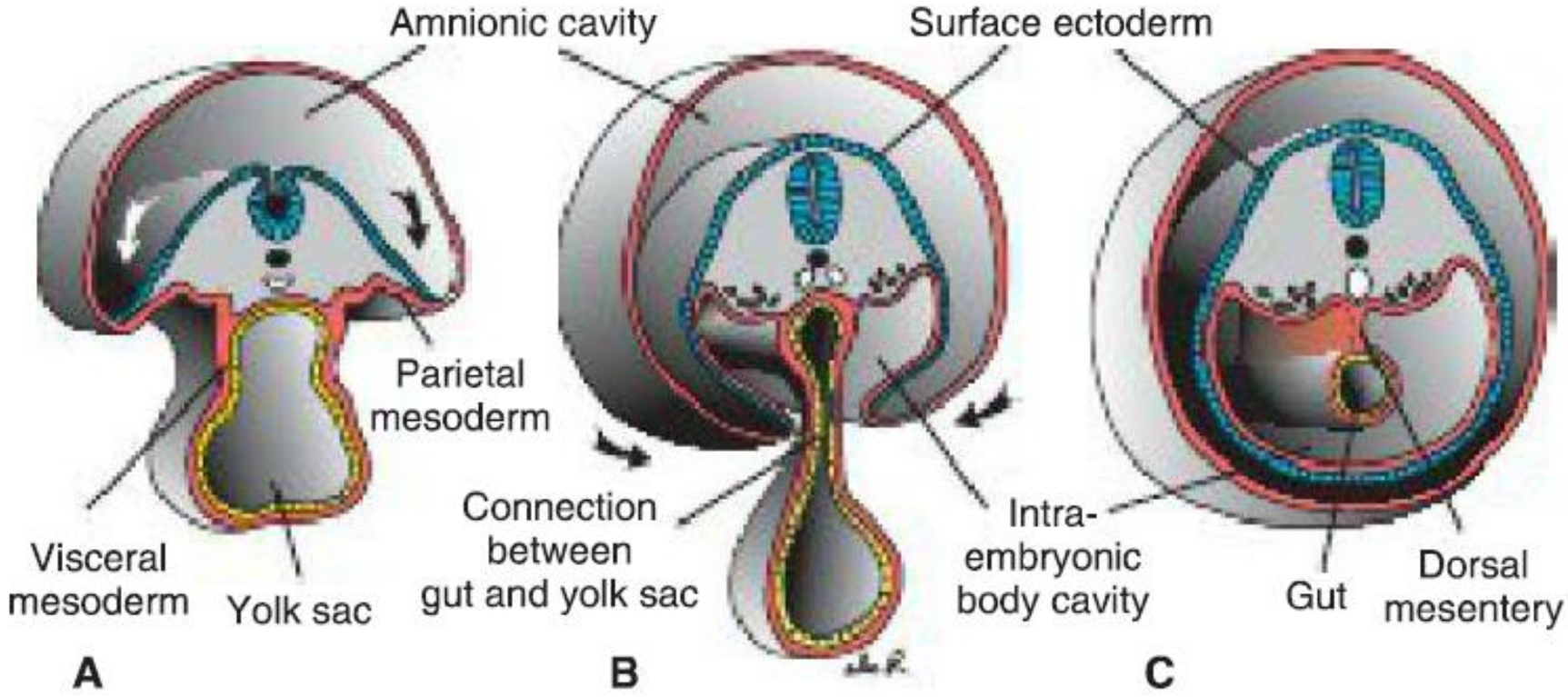

Allantois
Cloaca
Urorectal septum
Cloacal membrane
Hindgut
A
Primitive urogenital sinus
Proctodeum
B
Urogenital membrane
Urinary bladder
Perineal body
Anal membrane
Anorectal canal
C

- The **urorectal septum**, separates the region between the allantois and hindgut. This septum is derived from a **wedge of mesoderm** between the allantois and hindgut.
- At the end of the **seventh week**, the cloacal membrane ruptures, creating the anal opening for the hindgut and a ventral opening for the **urogenital sinus.**
- the urorectal septum forms the **perineal body**
- The upper part (2/3) of the anal canal is derived from endoderm of the hindgut; the lower part (1/3) is derived from ectoderm around the **proctodeum**

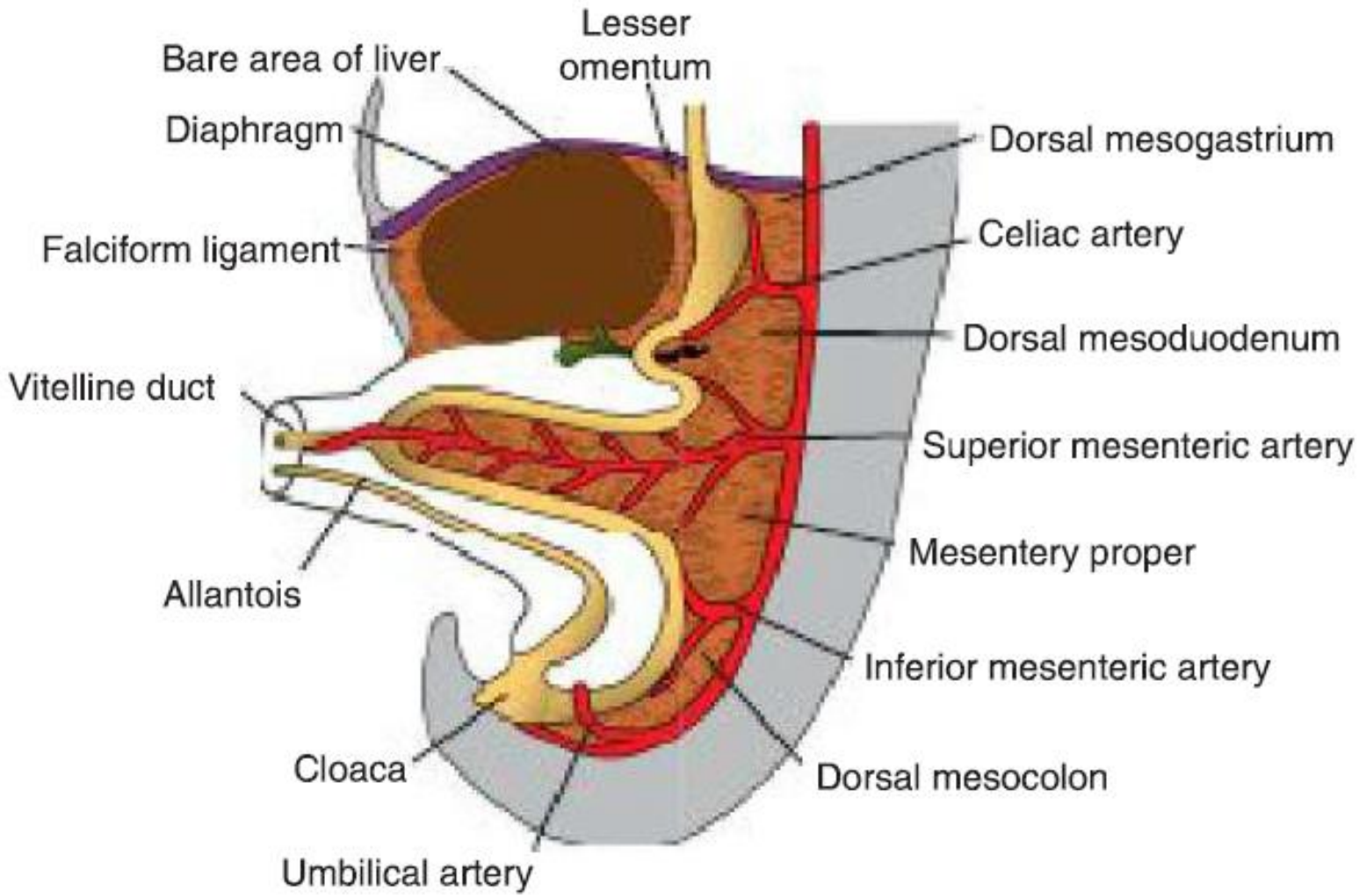
- region of the proctodeum on the surface of part of the cloaca proliferates and invaginates to create the **anal pit**.

Mesentery

- mesentery was defined as a double layer of peritoneum that encloses an organ and suspends it from the posterior abdominal wall.
- Initially, the foregut, midgut, and hindgut are in broad contact with the mesenchyme of the posterior abdominal wall.
- By the **fifth week**, this connecting tissue bridge has narrowed, and the caudal part of the foregut, the midgut, and a major part of the hindgut are suspended from the abdominal wall by the **dorsal mesentery.**


Amnionic cavity
Surface ectoderm
Parietal mesoderm
Visceral mesoderm
Yolk sac
Connection between gut and yolk sac
Intra-embryonic body cavity
Gut
Dorsal mesentery
A
B
C

- dorsal mesentery extends from the lower portion of the esophagus to the rectum as a continuous sheet of tissue attached to the posterior body wall and providing a pathway for blood vessels, lymphatics, and nerves to the gut tube and its derivatives.
- Various regions are named according to the parts of the gut tube to which they attach.
- These regions include: **the dorsal mesogastrium, greater omentum, mesoduodenum, mesentery proper** to small intestine, **mesocolon, mesoappendix, mesosigmoid, and mesorectum** to large intestine.


Bare area of liver
Lesser omentum
Diaphragm
Dorsal mesogastrium
Falciform ligament
Celiac artery
Dorsal mesoduodenum
Vitelline duct
Superior mesenteric artery
Mesentery proper
Allantois
Inferior mesenteric artery
Cloaca
Dorsal mesocolon
Umbilical artery

Liver and Gallbladder Abnormalities

- Variations in liver lobulation are common but not clinically significant. Accessory hepatic ducts and duplication of the gallbladder are also common and usually asymptomatic.
- **Extrahepatic biliary atresia**, the ducts, which pass through a solid phase in their development, fail to recanalize. This defect occurs in 1/15,000.
- Among patients with extrahepatic biliary atresia, 15% to 20% have patent proximal ducts and a correctable defect, but the remainder usually die unless they receive a liver transplant.

- **Intrahepatic biliary duct atresia**
- This rare abnormality [1/100,000 live births] may be caused by fetal infections.
- It may be lethal but usually runs an extended benign course.

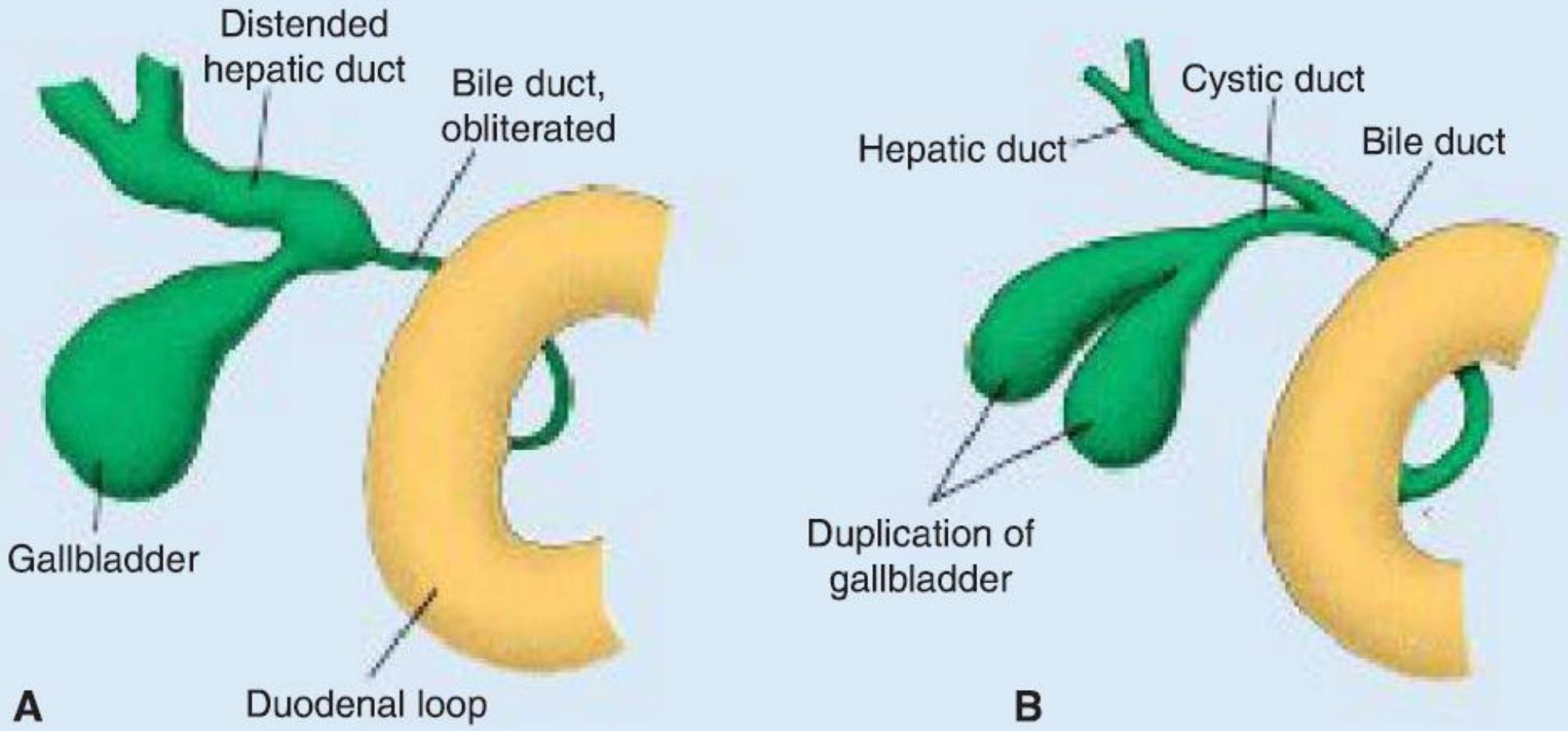
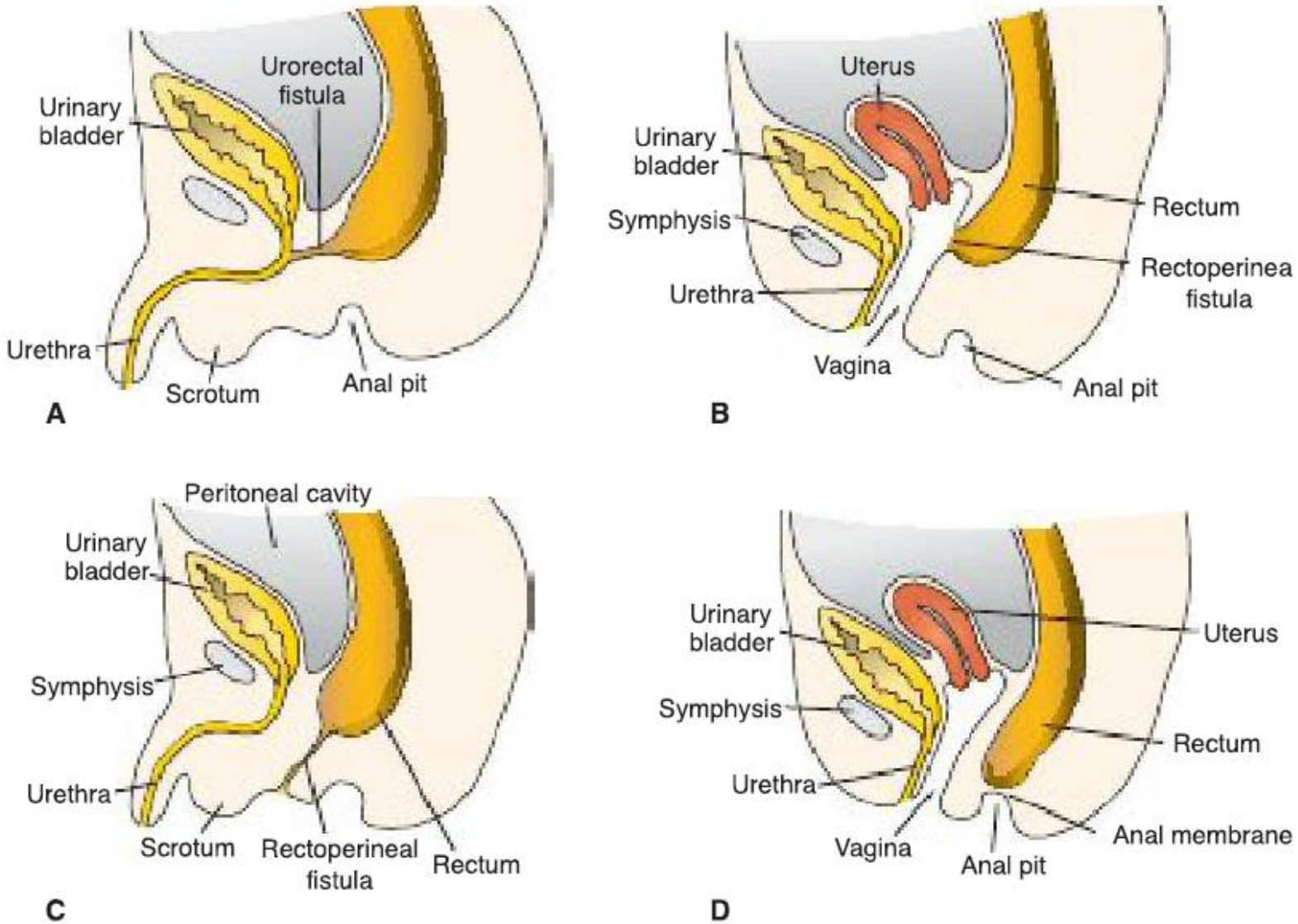


FIGURE 15.22 **A.** Obliteration of the bile duct resulting in distention of the gallbladder and the hepatic ducts distal to the obliteration. **B.** Duplication of the gallbladder.

- **Rectovaginal fistulas**
- which occur in l/5,000 live births, may becaused by abnormalities in formation of the cloaca and the urorectal septum

- **Rectoanal fistulas and atresias**
- vary in severity and may leave a narrow tube or fibrous remnant connected to the perineal surface. These defects are probably due to misexpression of genes during epithelial—mesenchymal signals.
- **Imperforate anus**
- the anal membrane fails to breakdown


Urorectal fistula
Urinary bladder
Urethra
Scrotum
Anal pit
A
Uterus
Urinary bladder
Symphysis
Urethra
Vagina
Rectum
Rectoperinea fistula
Anal pit
B
Peritoneal cavity
Urinary bladder
Symphysis
Urethra
Scrotum
Rectoperineal fistula
Rectum
C
Urinary bladder
Symphysis
Urethra
Vagina
Uterus
Rectum
Anal membrane
Anal pit
D

Thank you